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INT CL^6 **B29C 63/34 , F16L 55/165 58/10**

(54) Abstract Title
Liner pipe

(57) The liner pipe, 3 for installation into a host pipe 1, is prior deformed by axial folding to a reduced diameter G-shaped or spiral-shaped cross section, the deformed liner 3 being expandable from the reduced diameter to a larger diameter form of circular or ovular cross section when disposed within the host pipe 1 so as to conform more closely to the wall of the host pipe 1. The liner pipe is formed from a polyolefin homopolymer, a polyolefin copolymer, or a blend of a polyolefin and one or more other polymers, and has a final diameter over wall thickness ratio between 55 and 145, and a wall thickness in the range from 100 micrometres to 10 millimetres.

FIG. 2

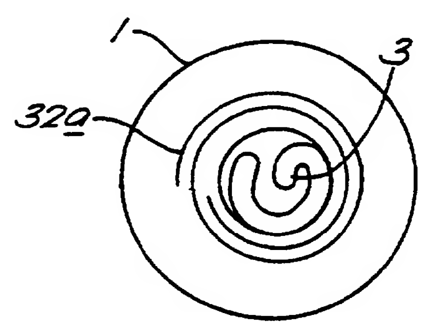

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FIG. 1

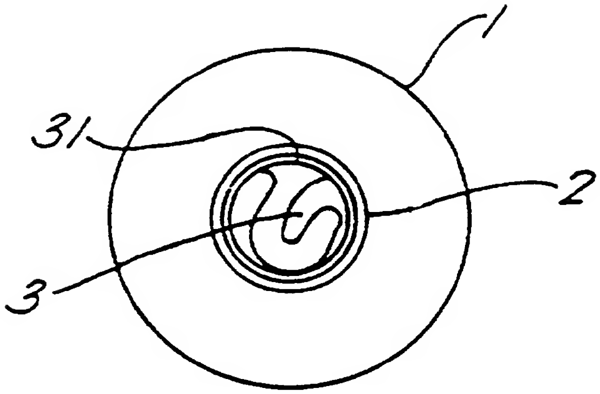


FIG. 2

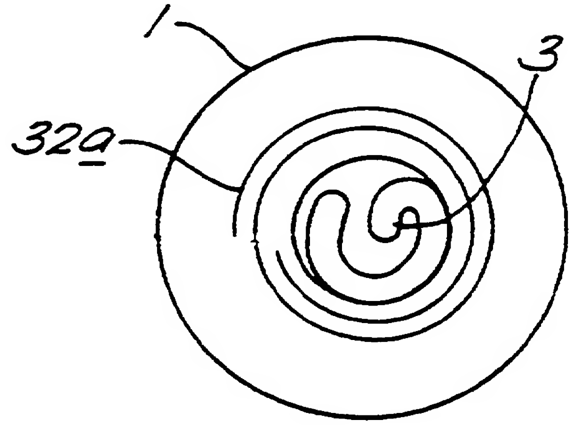


FIG. 3

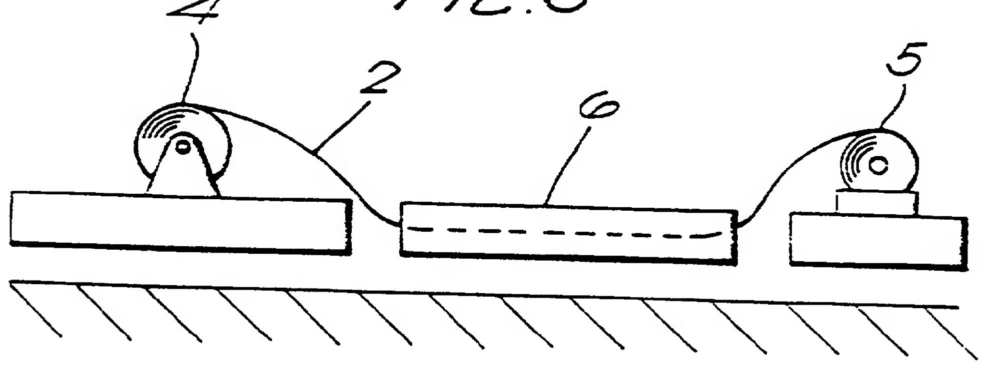


FIG. 4

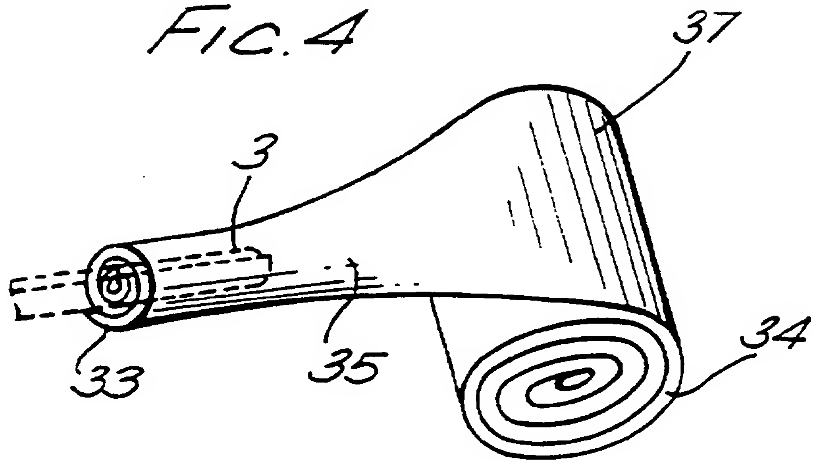


FIG. 5

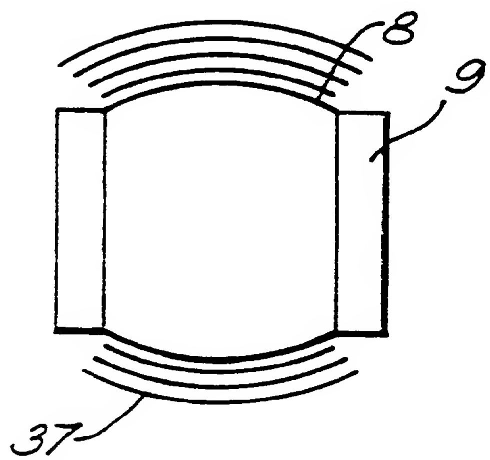
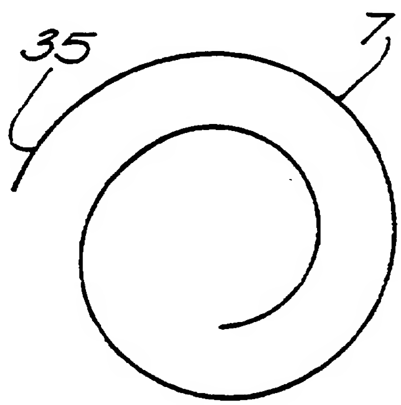


FIG. 6



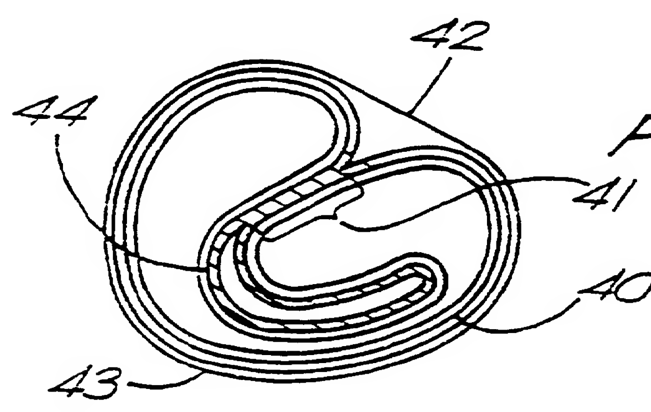


FIG. 7

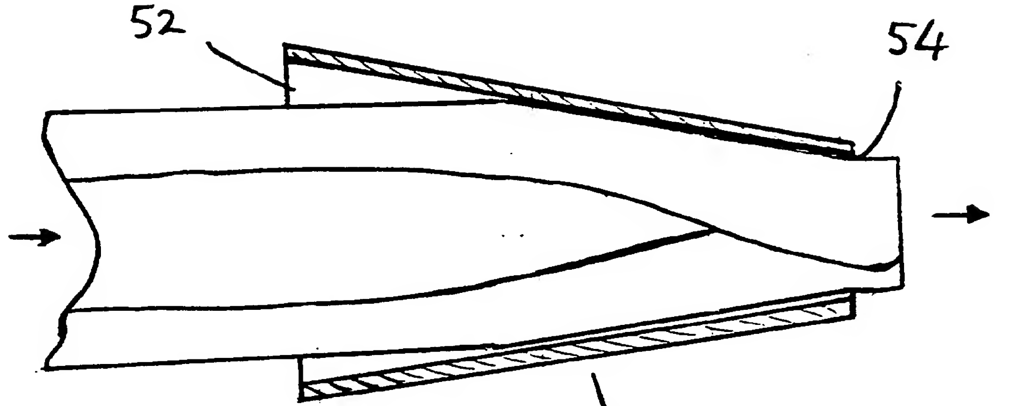


FIG. 10

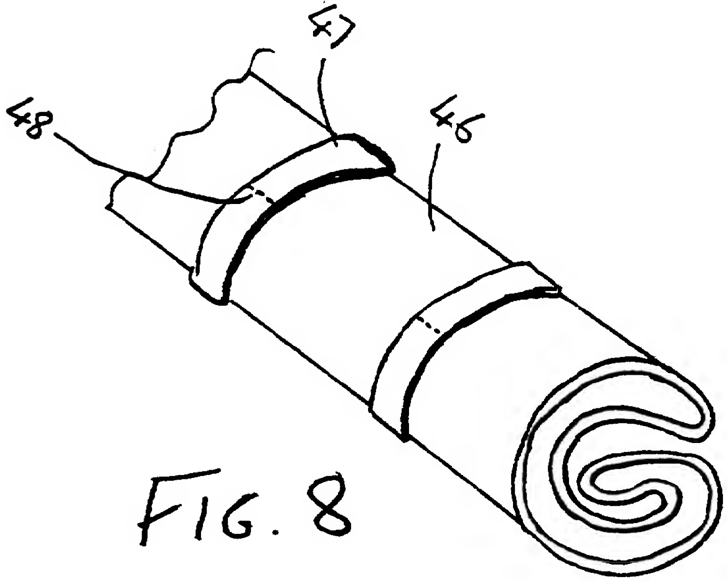


FIG. 8

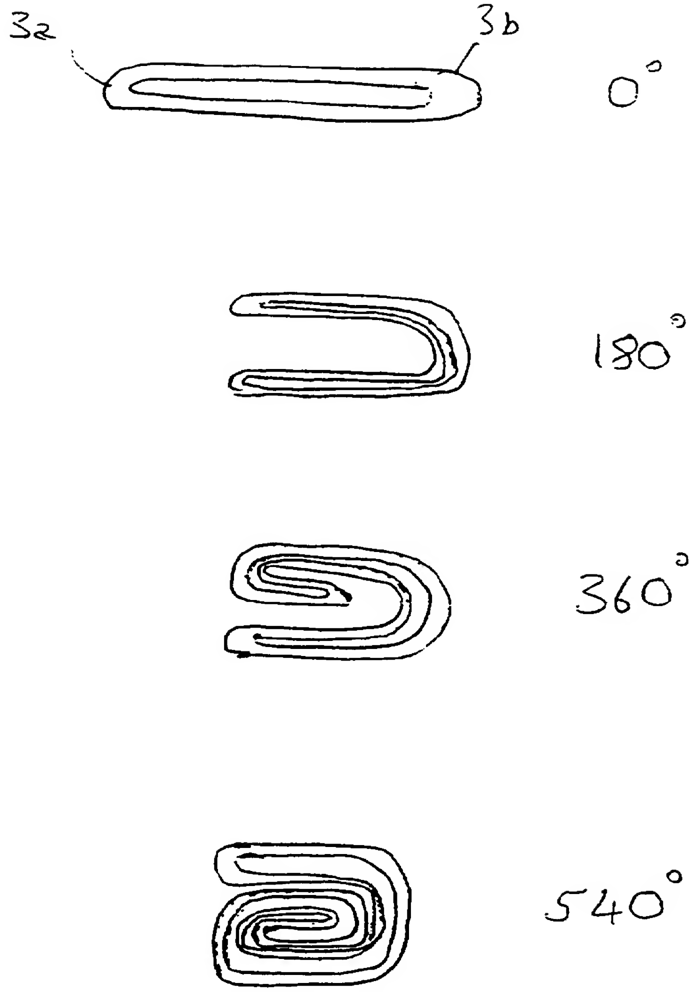


FIG. 9

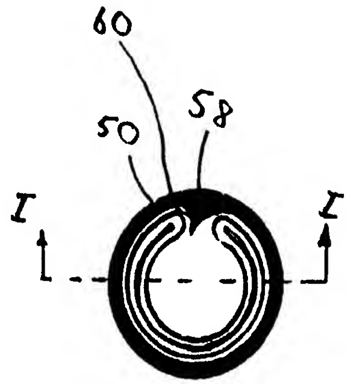


FIG. 11a

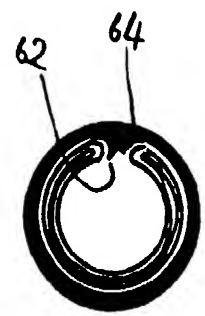


FIG. 11b

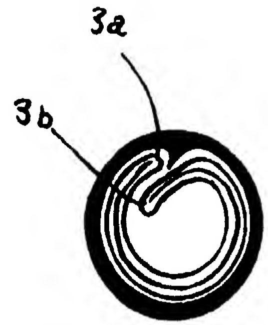


FIG. 11c

FIG. 11c

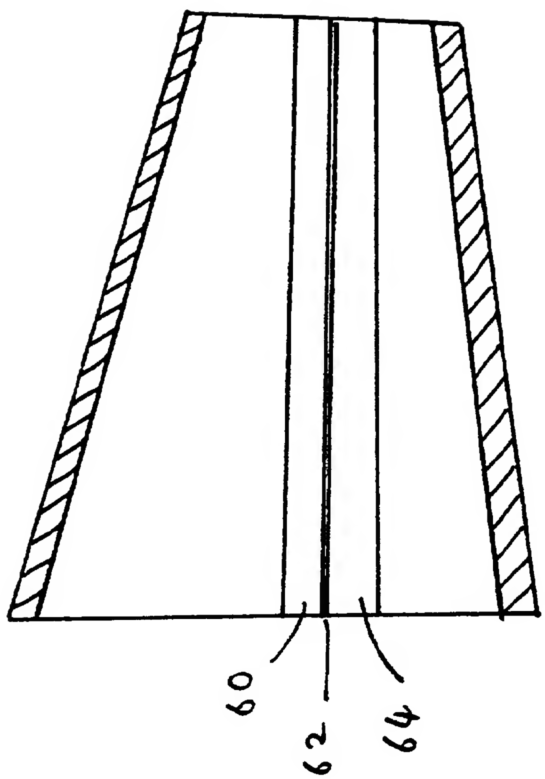


FIG. 12

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A LINER PIPE

This invention relates to a liner pipe for use in lining a pipeline, to methods of lining a pipeline and to pipelines thus lined.

In practice it is often desirable, with a damaged, faulty, and/or leaking pipe for example for water, where that pipe is reasonably structurally sound, not to replace the pipe nor to carry out a repair to the pipe as such, but to provide an impervious lining to that pipe to enable its satisfactory usable life to be extended.

To enable this to be achieved it has been proposed hitherto to insert into the faulty pipe in any disposition, a liner which has been deformed to be smaller than the host pipe to aid insertion and may be expanded to the internal diameter of the host pipe which will achieve the desired effect of sealing the pipe with respect to its faults and/or leakage, and provide many years further use for the lined pipe. Such a liner pipe may have a final diameter over wall thickness ratio typically between 60 and 26.

It has also already been proposed to replace damaged or faulty pipes, such as water mains, by passing an expandable or percussive destructive mole through the pipe and towing behind it a replacement pipe, or alternatively a protective sleeve for later insertion therethrough of a replacement pipe.

It has also been proposed in such a circumstance, to tow through the destroyed faulty pipe a two layered replacement pipe, the outer layer of which is of a hard nature, such as polypropylene, which may be adapted to resist or accommodate and accept the damage caused by fragments of the destroyed faulty pipe and the inner portion of which forms an appropriate new full pressure bearing pipe.

In addition it has been proposed to insert into an existing pipe a reduced diameter or deformed replacement pipe or liner pipe with relatively thick walls intended to be expanded to a round configuration within the host pipe. Such replacement pipes or liner pipes may have final diameter over wall thickness ratios typically between 33 and 10.

In all these instances, the liner pipe entered is of sufficient thickness to withstand the full or a substantial part of the internal pressure, and is intended to withstand or accommodate any abrasion damage as it is fed by being pushed and/or pulled into the host pipe, or the replacement pipe entered during or after destructive moling of an existing pipe is of sufficient thickness as above or incorporates an abrasion resistant outer layer. Such arrangements, although many of which are highly effective in the appropriate circumstances, are of course expensive in terms of installation and certainly in terms of the replacement pipe or liner pipe cost.

It has also been proposed to provide existing water mains, for example, with bore coatings of cementitious material such as concrete, or epoxy resin, in the latter case of a thin layer nature, to ensure protection of the pipe from the liquid or fluid (often water) passing therethrough or conversely protection of the fluid from contaminants in the host pipe due to corrosion or bacteriological formation for example. However such an arrangement does not necessarily provide protection against leakage, which is an increasing problem (as hereinabove indicated) at, for example, joints between the separate pipes making up the pipeline of a water main for

example.

According to the present invention there is provided a liner for installation into a host pipe to line the same; the liner pipe having been deformed by axial folding to a reduced diameter G-shaped or spiral-shaped cross section, the folded or deformed liner being expandable from the reduced diameter G-shaped or spiral-shaped cross section to a larger diameter form of circular or ovular cross section when disposed within the host pipe so as to conform more closely to the wall of the host pipe; provided that when the liner is G-shaped, it is formed from a polyolefin homopolymer, a polyolefin copolymer, or a blend of a polyolefin and one or more other polymers; and has a final diameter over wall thickness ratio between 55 and 145, and a wall thickness in the range from 100 micrometres to 10 millimetres.

In one embodiment of the invention, there is provided a liner for installation into a host pipe to line the same; the liner pipe having been deformed by axial folding to a reduced diameter G-shaped cross section, the folded or deformed liner being expandable from the reduced diameter G-shaped cross section to a larger diameter form of circular or ovular cross section when disposed within the host pipe so as to conform more closely to the wall of the host pipe; the liner being formed from a polyolefin homopolymer, a polyolefin copolymer, or a blend of a polyolefin and one or more other polymers; the liner having a final diameter over wall thickness ratio between 55 and 145, and a wall thickness in the range from 100 micrometres to 10 millimetres.

According to another embodiment of the invention, there is provided a liner for installation into a host pipe to line the same; the liner pipe having been deformed by axial folding to a reduced diameter substantially spiral-shaped cross section, the deformed liner being expandable from the reduced diameter spiral-shaped cross section to a larger diameter form of circular or

ovular cross section when disposed within the host pipe so as to conform more closely to the wall of the host pipe.

The term "G-shaped" as used herein refers to a cross sectional shape in which the liner has been substantially flattened to give two (usually radiussed) axial edges and then the flattened liner has been axially folded such that one axial edge has been folded through an angle of approximately 340 to 380 degrees with respect to the other edge. It will be appreciated that a G-shape can be considered to be a precursor to a spiral since further folding from the G-shape will lead to the formation of a spiral cross section. Accordingly, the term "spiral-shaped" as used herein refers to a cross sectional shape in which one axial edge of the flattened liner has been folded through an angle of greater than 380 degrees, more typically greater than 400 degrees, for example greater than 420 degrees, preferably greater than 450 degrees.

The term "folding" as used herein also includes "scrolling" or "rolling". It will be appreciated that for thicker walled liners, and for thin walled liners where the liner is deformed to a spiral, the deforming of the liner will more closely resemble a scrolling or rolling action.

The liner pipes of the present invention are substantially G-shaped or spiral-shaped in cross section and an advantage of this is that the spiral-shaped or G-shaped cross section is more compact and hence of substantially smaller diameter than a corresponding C-shaped or U-shaped deformed liner of equivalent initial undeformed diameter. By making the deformed liner even more compact, the radial clearance between the host pipe and liner pipe during installation is greater thereby making installation much easier and reducing the likelihood of damage to the liner. Furthermore, the more compact shape of the liner means that longer lengths can be accommodated on a reel and hence transport of the liner is rendered more efficient.

The term "final diameter" as used herein means the diameter of the liner when expanded *in situ* in the host pipe.

The liners of this invention can have a final diameter over wall thickness ratio between 55 and 145, more typically from 75 to 125.

The wall thickness of the liner typically is in the range from 100 micrometres to 25 millimetres, more typically 500 micrometres to 15 millimetres, for example up to 12 millimetres.

The liner typically is initially extruded in a form having a circular cross-section and is then flattened before axial folding into the spiral or G-shape. The folding process can be accomplished by hand, where the liner wall is thin enough, or by mechanical means. Folding into the spiral or G-shape can be accomplished mechanically by forcing the flattened liner into a conical chamber having a larger diameter opening at one end and a smaller diameter opening at the other end thereof, the liner entering the chamber through the larger diameter opening and being urged towards and through the smaller diameter opening, the liner being progressively folded through a C-shape to a spiral or G-shape cross section as it passes towards and through the smaller diameter opening.

The conical chamber can be provided with vibrating means for assisting movement of the liner along the walls of the chamber and to overcome frictional resistance to folding between contacting surfaces of the liner as it is folded. The liner may be lubricated to reduce friction between opposing surfaces thereof as it is folded and to reduce friction at the walls of the conical chamber.

The conical chamber can be provided with guide means for guiding the liner into a G-shape or spiral shape. The chamber can also be provided with stop means for holding one edge of the flattened liner against

circumferential movement whilst the other edge is folded into the G-shape or spiral shape. The guide means can take the form of a guide wall or flute disposed along the inner surface of the conical chamber. The guide wall or flute can be continuous or discontinuous along the length of the conical chamber, and can for example be defined by a series of discrete spaced guide lugs or protrusions. The guide wall can be shaped on one side thereof to define a stop for one edge of the flattened liner and can be shaped on the other side thereof so as to deflect the other edge of the liner radially inwardly and towards the spiral or G-shape configuration.

The conical chamber can be provided with means enabling it to be rotated about its main axis, rotation of the chamber serving to assist the folding process. It may, for example, be driven to produce a rotating movement in the direction of the G or spiral to urge the liner into the G-shape or spiral shape. However, it is important that the end of the liner at the narrow end of the conical chamber should not be rotated about its axis. When adapted to be rotatable, the conical chamber will not usually be provided with guide walls of the type hereinbefore defined so as to prevent twisting of the liner.

The conical chamber can be formed in sections along its axis, each section being separately rotatable and separately controllable. For example, each section can be separately controllable so as to produce different speeds of rotation. One section can, for example, be contra-rotated relative to its neighbouring section or sections. Each section can also be arranged for oscillatory rotational motion; i.e. each section can be arranged to rotate a very small distance in one direction followed by a very small distance in the other direction, the rotation-contra-rotation cycle being repeated at high speed to give a high frequency oscillation which helps overcome friction between confronting surfaces of the liner as it is folded. The oscillation of one section can be in phase with or out of phase with the oscillation of the adjoining section or sections. The oscillatory movement can be

superimposed over the normal macroscopic rotation of the sections. Alternatively, the sections can be held such that there is no net macroscopic rotation but only oscillatory motion.

It will be appreciated from the foregoing that in a further aspect, the invention provides a method of forming a liner of G-shaped or spiral shaped cross-section as hereinbefore defined.

After deformation, maintenance of the deformed G-shape can be assisted by securing means such as taping, wrapping, sleeving or tying, any of which could be helical or spiral in nature, or by heat deformation, or by the protective sleeve itself. For example, a plurality of ties or straps can be looped about the liner at intervals along the liner. Alternatively, a spirally wound wrapping tape or membrane can be wrapped about the liner to hold it in the deformed configuration. In a still further alternative, a sleeve can encircle the liner and can be either loosely arranged about the liner or a tight fit against the liner. When the sleeve is loosely fitted about the liner, securing means such as ties, tapes or the like will usually also be present to hold the liner in shape.

The securing means in general must be capable of expansion or rupturing in order to allow the liner to be expanded once it has been introduced into the bore of the host pipe.

Where a sleeve is employed as the securing means, it may be made of a sufficiently robust material to provide additional protection to the liner. The sleeve may be formed of a tube of any appropriate material or fabrication, such as polyethylene, polypropylene, nylon, woven mesh or impregnated or coated woven mesh or metal and may be loose or close fitted to the deformed liner before and/or during insertion of the deformed liner into the host pipe.

The dimensions and nature of the liner are chosen such that after insertion into the host pipe, by applying pressure and/or heat within the liner it will expand, substantially to fit the bore of the host pipe.

Accordingly, the invention also provides a method of lining a faulty, damaged and/or leaking pipe line comprising inserting into the pipe line a deformed liner as hereinbefore defined, and then applying pressure and/or heat within the liner such that it expands substantially to fit the bore of the host pipe.

In order to prevent damage to the liner during insertion into the host pipe or pipeline, for example by abrasion or contact with sharp edges of damaged regions of the pipe, a protective outer sleeve may be employed. The protective outer sleeve can be arranged about the deformed liner after the deforming step but before insertion into the pipe, or the sleeve can be inserted into the pipe first to provide a protective lining and then the liner can be inserted. The sleeve can be formed such that either it can be removed from the pipe after insertion of the deformed liner and prior to expansion, or it can be formed such that it expands or ruptures during the subsequent expansion of the liner.

Accordingly, in another aspect of the invention, there is provided a method of lining a faulty, damaged and/or leaking pipe line comprising inserting into the pipe line a protective sleeve initially of smaller outside diameter than the inner diameter of the pipe line and providing within the protective sleeve a liner as hereinbefore defined, the liner being protected during its insertion by the protective sleeve; applying pressure and/or heat within the thin wall liner, the arrangement and dimensions and nature of the thin wall liner being such that upon or shortly after such application within the thin wall liner it expands substantially to fit the bore of the host pipe.

Where the protective sleeve is retained within the host pipe, the

arrangement and dimensions and nature of the liner and the sleeve are such that upon or shortly after application of pressure and/or heat within the liner, it expands or bursts the sleeve substantially to fit the bore of the host pipe.

The protective sleeve may have a final diameter over wall thickness ratio typically between 50 and 300.

The invention is particularly applicable to host pipes of the type which are intended to contain at least lightly pressurised materials such as liquids or gases, and in particular to host pipes where the maintenance of internal pressures is important. Examples of such host pipes include those intended to carry water or gas, although other circumstances can be readily envisaged. The host pipes can be formed from, for example, cast iron, steel, plastics, concrete or earthenware and may be formed in a wide range of diameters. For example, in the context of water and gas distribution systems, the host pipes can be between 1.25cm (0.5") nominal diameter and 122cm (48") nominal diameter.

The liners of the invention can be can have walls of a unilaminar construction or a multilaminar construction. For example, where the liner is intended for use in carrying hydrocarbon materials, or where it is intended to be used to carry services such as drinking water through hydrocarbon contaminated soil, the liner can be formed in several layers, a main structural layer and a barrier layer for enhancing the resistance to hydrocarbon permeation.

In order that the invention may be more readily understood embodiments thereof will now be described by way of example with reference to the accompanying drawings in which:-

Figures 1 and 2 illustrate in section and schematically typical alternative arrangements of a host pipe together with protective sleeves and

deformed thin wall liners disposed therein prior to enlargement of the deformed thin wall liners;

Figure 3 illustrates schematically a method of carrying out an installation in accordance with the invention;

Figures 4 and 5 illustrate a flattened protective sleeve with its supporting drum;

Figure 6 shows a transverse sectional view of the respective protective sleeve when released from the drum;

Figure 7 illustrates in schematic section an alternative arrangement of liner and sleeve; and

Figure 8 illustrates a liner according to another embodiment of the invention;

Figure 9 illustrates schematically the folding of liners into various configurations;

Figure 10 illustrates schematically an apparatus for deforming the liner to a G-shaped cross section;

Figures 11a to 11d are schematic cross sectional views through an apparatus of the type shown in Figure 10 but provided with guide means for assisting the folding of the liner; and

Figure 12 is a section along line I-I in Figure 11.

As can be seen from Figure 1, in one embodiment of the invention, there is provided a deformed liner 3 held in its deformed state by protective

sleeve 2. The deformed liner is formed from a blend of polymers comprising a crystalline polyethylene and an amorphous elastomeric material such as a chlorinated polyolefin. In this embodiment, the liner has a wall thickness of 1mm and a final diameter over wall thickness ratio of 100. As shown in Figure 1, the deformed liner 3 and its associated protective sleeve 2 have been inserted into a host pipe 1 which may, for example, form part of a cast iron pipeline. The protective sleeve 2 may either be left within the host pipe 1 after installation of the liner, or alternatively may be withdrawn after such installation.

The liner 3 is initially formed in conventional fashion by extruding through a circular die (not shown) to give a thin walled liner of circular cross section (not shown). The thinness of the wall of the liner means that it can easily be folded into a flattened configuration (see Figure 9a) having two axial folds or edges 3a and 3b. If the walls are sufficiently thin and pliable, the liner can be folded or rolled up by hand into a G-shape or spiral shape. As will be apparent from Figures 9a to 9e, if the liner 3 is initially folded into a C-shape (Figure 9b), the edge 3b is turned or folded through 180 degrees with respect to the other edge 3a, and if the liner is folded still further into a G-shape cross section (Figure 9c), the edge 3b will then have been folded through 360 degrees. Further folding into a spiral shape will involve turning or folding the edge 3b through 540 degrees relative to edge 3a and its original configuration.

In the drawings, the folded liner is shown as being relatively flat in form, but it need not be. Depending on the original diameter of the liner, the thickness of its walls, and the number of folds, the cross section of the folded liner could be more circular in form, or less circular in form. For example, if the walls are relatively thick, the starting diameter is relatively small, and the number of folds is relatively large, the resulting liner pipe would have a folded cross-section approaching circularity. Conversely, if the number of folds is relatively small, the initial diameter of the liner is relatively

large and the wall of the liner is relatively thin, then a more flattened profile would result from the axial folding.

Although the liner can be folded by hand; as an alternative, a mechanical means can be used to perform the folding or rolling. For example, the liner can be folded by urging it into or drawing it through a conical chamber 50 having a larger diameter opening 52 at one end and a smaller diameter opening 54 at the other end thereof, as shown in Figure 10. The liner 3 can be forced through the chamber 50 by a force applied from behind, or it can be towed through the chamber. As can be seen from Figures 11a to 11d, the liner 3 enters the chamber through the larger diameter opening 52 and is urged towards and through the smaller diameter opening 54, the liner being gradually compressed into a spiral or G-shape cross section as it passes towards and through the smaller diameter opening 54. After emerging from the opening 54, straps, ties, a wrapping or a sleeve can be applied to the deformed liner to hold it in the deformed state.

In order to assist the folding and compressing process, a guide wall 58 can be provided, as shown in Figures 11 and 12. Guide wall 58 projects radially inwardly into the chamber from the wall of the cone, and extends along the entire length of the chamber. It is shown as a continuous wall but need not be and could be constituted by, for example, a row of individual guiding lugs. On one side of the guide wall, the surface 60 has a relatively small radius of curvature and the radially inner end of the surface defines a lip 62 which serves as a stop and holds the edge 3a of the flattened liner against radially inwards displacement. The other side 64 of the guide wall has a larger radius of curvature.

As can be seen from Figures 11a to 11d, as the liner is advanced into the conical chamber, the edges 3a and 3b are deflected inwardly, edge 3a coming to rest against the surface 60 of the guide wall 58 and being held against further movement circumferentially by means of the lip 62. As the

liner 3 is advanced further into the chamber, edge 3b comes into contact with surface 64 of the guide wall and is deflected radially inwardly to form a G-shape. Further movement of the liner along the cone and consequent further compression of the liner causes the liner to form into a spiral as shown in Figure 11d. Of course, the dimensions of the chamber can be chosen such that the folding process stops at the G-shape rather than progressing on to the spiral shape.

As will be appreciated from the drawings, the overall diameter of the liner following forming/compression/folding to the G-shape or spiral shape is significantly less than the diameter of the corresponding C-shape or U-shape. For example, for a liner of 0.1 cm. wall thickness and 10 cm. initial (i.e. before initial deformation to a C-shape or U-shape) diameter, the difference in diameter between the G-shape and the U-shape and C-shape can be as much as 33%. For a spiral configuration, the difference in diameter for a liner of 0.4 cm. and wall thickness of 40 cm. initial diameter can be as much as 50% or more. This greatly increases the radial clearance about the liner when inserted into the host pipe 1 and therefore makes installation easier and reduces still further the possibility of damage to the liner. In addition, the greater compactness of the liner means that much longer lengths of liner can be accommodated on a given reel or drum, and the general ease of handling and transporting is greatly increased.

Figure 2 shows a liner pipe assembly generally similar to the assembly of Figure 1 except that a tightly fitting longitudinally slit and circumferentially overlapping protective 32a sleeve is installed as shown.

Figure 8 shows a liner pipe 46 generally similar to the liner pipe 3 in Figure 1 except that in this case, rather than having a tight fitting protective sleeve to hold it in the deformed configuration, a series of straps or ties 47 are disposed about the liner at intervals along its length. In order to assist rupturing during subsequent expansion of the liner 46, the straps 47 can be

provided with a line of weakness 48, for example in the form of an array of perforations.

Referring to Figure 3, the method of installation illustrated shows a reel 4 around which a protective sleeve 2 is wound, incorporating therewithin the liner (not shown), which combination is drawn through the host pipe 6 by means of a winch 5 for example at the far end thereof.

Alternatively, but not illustrated, a protective sleeve may be inserted separately into a host pipe, and a liner then inserted into the protective sleeve. The liner 3, 46 may be held in its compact shape by straps 47 for example as previously described. Subsequently, the protective sleeve may be withdrawn from the host pipe leaving the liner in the host pipe for expansion therein, or alternatively the protective sleeve housing the liner may be left within the host pipe trapped between the liner and the host pipe.

Where the protective sleeve is to be withdrawn from the host pipe, it may be arranged to be that of a heavy duty high burst characteristic sleeve, or (to aid withdrawal) a longitudinally slit sleeve. Where the protective sleeve is left within the host pipe, this may well be of a low burst characteristic nature or again may be a longitudinally slit sleeve.

Once the liner 3, 46 has been inserted into the host pipe and the protective sleeve, if present, optionally withdrawn, the liner is subjected to pressurising and/or heating sufficient to cause it to burst its wrapping or sleeving or ties if any of these arrangements is installed, and then to cause the protective sleeve (if still present) to be burst or expanded and then to force all the elements of the installed system generally radially outwardly out to be close to or in contact with the host pipe bore.

Alternatively the protective sleeve may be withdrawn from the host pipe prior to pressurising and/or heating the deformed liner or again

alternatively the protective sleeve may be withdrawn from the host pipe at some convenient stage after it has been caused to burst by the pressurising and/or heating of the initially deformed liner. Thereafter the initially deformed liner may continue to be pressurised and/or heated to cause it to expand with its burst wrapping, sleeving or ties if any be present until all the installed elements of the system are close to or in contact with the hose pipe bore.

Lubricant may be used to reduce friction between any of the interfaces of the host pipe, protective sleeve, and thin walled liner during insertion or withdrawal.

Alternatively water flow, or other fluid flow, may be used to assist insertion or withdrawal between any of the interfaces. Frustroconical fins for example may be added to the external wall of the protective sleeve or to the wrapping of the deformed liner to assist in the insertion and/or withdrawal thereof using a constant or fluctuating flow between the protective sleeve and the host pipe or between the deformed liner wrapping and the protective sleeve.

The protective sleeve may be slit longitudinally over its own length, or rendered easy to burst by intermittent slitting or some other form of weakening such as intermittent holing or piercing.

Where the protective sleeve is of a longitudinally slit nature, this would typically have a total circumference greater than the deformed liner external circumference, and also greater than the circumference of the host pipe bore. Such a sleeve could be manufactured so as to provide residual hoop stresses that would cause the edges created by longitudinally slitting to overlap. Such a slit protective sleeve can in certain circumstances be easier to insert in the host pipe than an equivalent diameter complete tube due to its reduced circumferential and torsional stiffness, and the potential

for reduced diameter with increasing overlap. In addition advantageously during insertion of and after the pressurising of the thin wall liner, the slit sleeve would be easily opened out radially onto the internal host pipe wall even if it were of sufficient thickness to accommodate abnormally abrasive conditions during its insertion into the host pipe.

In order to avoid the problems of transporting a slit sleeve to the work site in the long lengths that would be required without creasing or kinking which could result from winding/unwinding from a reel, drum or coil, the slit tubular member may be progressively opened out. This is illustrated in Figures 4 and 5. The plastics material 7 in an overlapping state is rolled or wound onto a drum 9 as a relatively flat sheet 34 (or alternatively similarly wound or rolled into a free standing roll (not shown)). On subsequently unwinding the near flat strip 37 from drum 9 (which may have a convex receiving surface 8 for the receipt of the strip 37) it may readily revert back into a tube 35 having a similar amount of longitudinal edge overlap 33 to that which existed prior to opening out, flattening and winding flat. This memory recovery back into a slit tube with overlapping edges is optimised if the slit tube after opening out and flattening is wound in the radial plane in the direction originally towards the slit side from the 180^0 opposite unslit side. The rolled flattened slit sleeve 37 is shown to be slightly convex on its shaped drum, because this may promote more stable winding and/or a faster subsequent recovery after unwinding.

Alternatively, the slit tube can be formed so that it has overlapping edges after unwinding from its opened out and flattened state, by heating it with an appropriate heating means while it is constrained in an overlapping state, and holding it in the heated constrained state for an appropriate length of time.

Such a protective slit sleeve may be weakly held together at its overlapping edges either by means of tape or wrapping for example or (to

obviate the risk of abrasion damage) by welding or deploying an adhesive disposed under the external overlapping edge.

Such a transversely opened out and longitudinally rolled up slit sleeve as illustrated in Figures 4, 5 and 6 may be inserted into the host pipe before inserting the deformed liner 3.

Alternatively such a protective and/or constraining slit sleeve could be fed over a constrained or unconstrained liner 3 (shown dotted in Figure 4 for example) during or after manufacture of the thin wall liner before or during the insertion of same into the host pipe.

Figure 7 illustrates a further arrangement of the invention in which a liner 40 has itself been made (for example, in circular cross section) in multi layer form, the outer layer being a weakly bonded, or unbonded abrasion resistant or abrasion accommodating layer .

The multi-layered tubular liner is deformed as in other embodiments, and the deformed shape constrained, without any degradation risk to the inner layer or layers of the liner, by means of an adhesive or spot or seam weld 41 for example along the point of contact between the outer layer or by any of the constraining means previously described, such as taping 42, wrapping, sleeving or tying, any of which could be helical or spiral in nature, or by heat deformation.

The weakly bonded, or unbonded abrasion resistant or abrasion accommodating outer layer 43 itself may be readily burstable at a later stage of the liner reversion process subsequent to the weld or bond or any of the previously described constraining means being broken. This may be achieved for example by incorporating a reduced thickness over part or all of that longitudinal region of the outer layer which is contained within the folds of the deformed multi layer 44 lining and therefore would not be

exposed to abrasion risks during insertion into the host main.

This last embodiment allows the use of a hard and relatively inflexible outer layer in the manner described, but which use would not prevent the ready reversion and expansion of the multi layered deformed liner into close proximity with the host pipe bore (where this latter has an internal circumference greater than that of the liners manufactured overall outer circumference), or alternatively would not cause the liner to retract elastically back sufficiently from the host pipe bore (when the main is depressurised for maintenance for example) to reduce significantly the buckling resistance of the installed liner to ground water pressure via leaking joints for example in the host pipe.

An advantage of the invention is that it provides mainly by use of thin wall linings as defined hereinabove, a generally more economic lining method compared to the earlier mentioned lining methods primarily as the result of using cheaper materials and more economic techniques for handling and installation.

It is to be understood that the foregoing is merely exemplary of methods of lining pipes, and means therefore in accordance with the invention and that modifications can readily be made thereto without departing from the true scope of the invention.

CLAIMS

1. A liner for installation into a host pipe to line the same; the liner pipe having been deformed by axial folding to a reduced diameter G-shaped or spiral-shaped cross section, the deformed liner being expandable from the reduced diameter G-shaped or spiral-shaped cross section to a larger diameter form of circular or ovular cross section when disposed within the host pipe so as to conform more closely to the wall of the host pipe; provided that when the liner is G-shaped, it is formed from a polyolefin homopolymer, a polyolefin copolymer, or a blend of a polyolefin and one or more other polymers; and has a final diameter over wall thickness ratio between 55 and 145, and a wall thickness in the range from 100 micrometres to 10 millimetres.

2. A liner for installation into a host pipe to line the same; the liner pipe having been deformed by axial folding to a reduced diameter G-shaped cross section, the deformed liner being expandable from the reduced diameter G-shaped cross section to a larger diameter form of circular or ovular cross section when disposed within the host pipe so as to conform more closely to the wall of the host pipe; the liner being formed from a polyolefin homopolymer, a polyolefin copolymer, or a blend of a polyolefin and one or more other polymers; the liner having a final diameter over wall thickness ratio between 55 and 145, and a wall thickness in the range from 100 micrometres to 10 millimetres.

3. A liner for installation into a host pipe to line the same; the liner pipe having been deformed by axial folding to a reduced diameter substantially spiral-shaped cross section, the deformed liner being expandable from the reduced diameter spiral-shaped cross section to a larger diameter form of circular or ovular cross section when

disposed within the host pipe so as to conform more closely to the wall of the host pipe.

4. A liner according to any one of the preceding claims having a final diameter over wall thickness ratio between 75 and 125.

5. A method of forming a liner of G-shaped or spiral shaped cross-section as defined in any one the preceding claims which method comprises extruding the liner in a form having a circular cross-section, flattening the liner and then subjecting the liner to axial folding into the spiral or G-shape.

6. A method according to claim 5 wherein the step of folding the liner into the spiral or G-shape is accomplished mechanically by forcing the flattened liner into a conical chamber having a larger diameter opening at one end and a smaller diameter opening at the other end thereof, the liner entering the chamber through the larger diameter opening and being urged towards and through the smaller diameter opening, the liner being progressively folded through a C-shape to a spiral or G-shape cross section as it passes towards and through the smaller diameter opening.

7. A method according to claim 6 wherein the conical chamber is provided with vibrating means for assisting movement of the liner along the walls of the chamber and to overcome frictional resistance to folding between contacting surfaces of the liner as it is folded.

8. A method according to claim 6 or claim 7 wherein the liner is lubricated to reduce friction between opposing surfaces thereof as it is folded and to reduce friction at the walls of the conical chamber.

9. A method according to any one of claims 6 to 8 wherein the conical

chamber is provided with guide means for guiding the liner into a G-shape or spiral shape.

10. A method according to any one of claims 6 to 9 wherein the chamber is provided with stop means for holding one edge of the flattened liner against rotational movement whilst the other edge is folded into the G-shape or spiral shape.

11. A method according to claim 9 wherein the guide means can take the form of a guide wall or flute disposed along the inner surface of the conical chamber.

12. A method according to claim 9 or claim 11 wherein guide wall or flute is continuous along the length of the conical chamber.

13. A method according to claim 10 and any one of claims 9, 11 and 12 wherein the guide wall is shaped on one side thereof to define a stop for one edge of the flattened liner and is shaped on the other side thereof so as to deflect the other edge of the liner radially inwardly and towards the spiral or G-shape configuration.

14. A method according to any one of claims 6 to 8 wherein the conical chamber is provided with means enabling it to be rotated about its main axis, rotation of the chamber serving to assist the folding process.

15. A method according to claim 14 wherein the conical chamber is formed in sections along its axis, each section being separately rotatable and separately controllable.

16. A method according to claim 15 wherein each section is arranged for oscillatory rotational motion.

17. A liner substantially as described herein with reference to the accompanying drawings.

18. A method of forming a liner substantially as described herein with reference to the accompanying drawings.

19. A method of lining a faulty, damaged and/or leaking host pipe line comprising inserting into the host pipe line a deformed liner as defined in any one of the preceding claims, and then applying pressure and/or heat within the liner such that it expands substantially to fit the bore of the host pipeline.

20. A method of lining a faulty, damaged and/or leaking host pipe line comprising inserting into the host pipe line a protective sleeve initially of smaller outside diameter than the inner diameter of the host pipe line and providing within the protective sleeve a liner as defined in any one of the preceding claims, the liner being protected during its insertion by the protective sleeve; applying pressure and/or heat within the liner, the arrangement and dimensions and nature of the liner being such that upon or shortly after such application within the liner it expands substantially to fit the bore of the host pipe line.

The Patent Office

23.

Application No: GB 9716245.7
Claims searched: 1-20
Examiner: Roger Binding
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Amended Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F2P (PC12, PC13, PC27, PC29, PF5, PM9, PTBL)

Int Cl (Ed.6): F16L 55/165, 58/10; B29C 63/34

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 2003576 A	(TRIO ENGINEERING), see page 3, lines 25 to 29, 45 and 46.	1, 2
Y	EP 0098547 A1	(TRIO ENGINEERING), see page 8, line 31, to page 9, line 6.	1, 2
Y	WO 96/01937 A1	(DRILLFLEX), see especially Fig 3.	Y -1, 2, 19
X, Y	WO 83/03131 A1	(FORSHEDA INNOVATION), see Fig 3 and page 4, line 35, to page 5, line 21.	X - 3-5, 19 Y - 1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		